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Dept. of Environmental Quality
Waste & Underground Tank
Tank Management Bureau

DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2015 GROUNDWATER QUALITY DATA

CITY OF HELENA LANDFILL

Prepared For:

CITY OF HELENA
HELENA, MONTANA

Hydrometrics, Inc.
consulting scientists and engineers

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MARCH 2016

Hydrometrics, Inc.
consulting scientists and engineers

3020 Bozeman Avenue
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(406) 443-4150
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Dept. of Environmental Quality
Waste & Underground
Tank Management Bureau

March 22, 2016

Mr. John Collins
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

RE: Statistical Evaluation of December 2015 Groundwater Quality Data

Dear John,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in December 2015. After receiving approval from Pete Anderson of the City of Helena, I am forwarding a copy of the report "Data Validation and Statistical Evaluation of December 2015 Groundwater Quality Data City of Helena Landfill" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: Randall Camp, City of Helena, without Enclosure
Pete Anderson, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

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Dept. of Environmental Quality
Water & Underground
Tank Management Bureau

DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2015 GROUNDWATER QUALITY DATA

CITY OF HELENA LANDFILL

Prepared for:

Mr. Randall Camp
City of Helena
City/County Building
316 North Park Avenue
Helena, MT 59623

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

March 2016

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DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2015 GROUNDWATER QUALITY DATA

CITY OF HELENA LANDFILL

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the December 2015 monitoring event, summarizes the data validation results, and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.1305(8) and ARM 17.50.1305(9) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

- Concentrations of PCE are decreasing over time in well EPA-1, the well that has historically shown the highest concentrations, and in compliance wells HL-90-1, HL-99-1, and HL-99-3; and
- Elevated nitrate plus nitrite as N (nitrate) concentrations exist both upgradient and downgradient of the landfill at similar levels.

These findings are further evaluated in this December 2015 statistical report through an assessment of current concentrations (Table 4-1), a comparison of summary statistics (Tables 4-2 and 4-3), an inter-well prediction analysis (Table 4-4) and an examination of temporal trends (Table 4-5 and Figures 4-1 and 4-2).

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial, and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was originally capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater. In 2010, the entire landfill area was resurfaced and landscaped as part of the Centennial Park expansion and renovation project. New backfill material was brought in to bring the entire area to project grades and the cap depth now varies between two feet and more than 8 feet in some areas.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill are included in the groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1, HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), eight of these wells were included in the December 2015 sampling event. The locations of these wells are shown in Figure 2-2.

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, recreational, and industrial zoned property. There are several businesses adjacent of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1970s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was originally capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater. In 2010, the entire landfill area was resurfaced and landscaped as part of the Centennial Park expansion and renovation project. New landfill material was brought in to bring the entire area to project grades and the cap depth now varies between two feet and more than 8 feet in some areas.

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- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-3;
- Downgradient wells: HL-10-1, HL-99-1, HL-99-2, HL-99-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3 and in accordance with the approved sampling and analysis plan (Hydrocomplex, 2006), eight of these wells were included in the December 2015 sampling event. The locations of these wells are shown in Figure 2-2.

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF DECEMBER 2015
GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE
2-1

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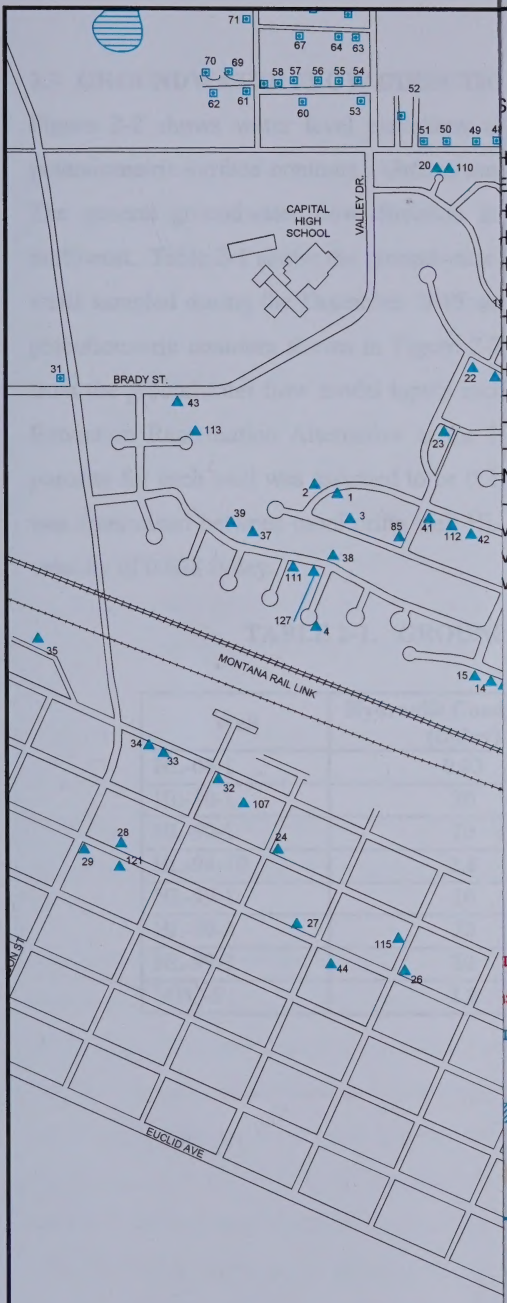

SITE CODE	DTWL	MPE	SWL
	Dec-15		
HL-06-1	16.49	3993.62	3977.13
EPA-1	45.28	3981.08	3935.80
HL-10-1	53.43	3943.01	3889.58
HL-90-1	52.75	3942.48	3889.73
HL-90-2	46.00	3950.96	3904.96
HL-90-3	57.28	3958.29	3901.01
HL-94-1R	56.34	3994.04	3937.70
HL-94-2R	34.87	3967.64	3932.77
HL-94-3	34.96	3967.38	3932.42
HL-99-1	53.45	3943.15	3889.70
HL-99-2	54.43	3945.75	3891.32
HL-99-3	49.94	3948.05	3898.11
NF. GALLE	5.88	3918.89	3913.01
-1	59.91	3899.59	3839.68
MPC-1	22.44	3946.08	3923.64
MPC-2	16.99	3936.09	3919.10
MPC-5	53.65	3990.14	3936.49

NORTH

SCALE

0 (In Feet) 800

LEGEND

- L-1 ■ PIEZOMETER
- 3-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 ▣ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

DY AREA AND DECEMBER 2015
OTENTIOMETRIC SURFACE

FIGURE
2-2

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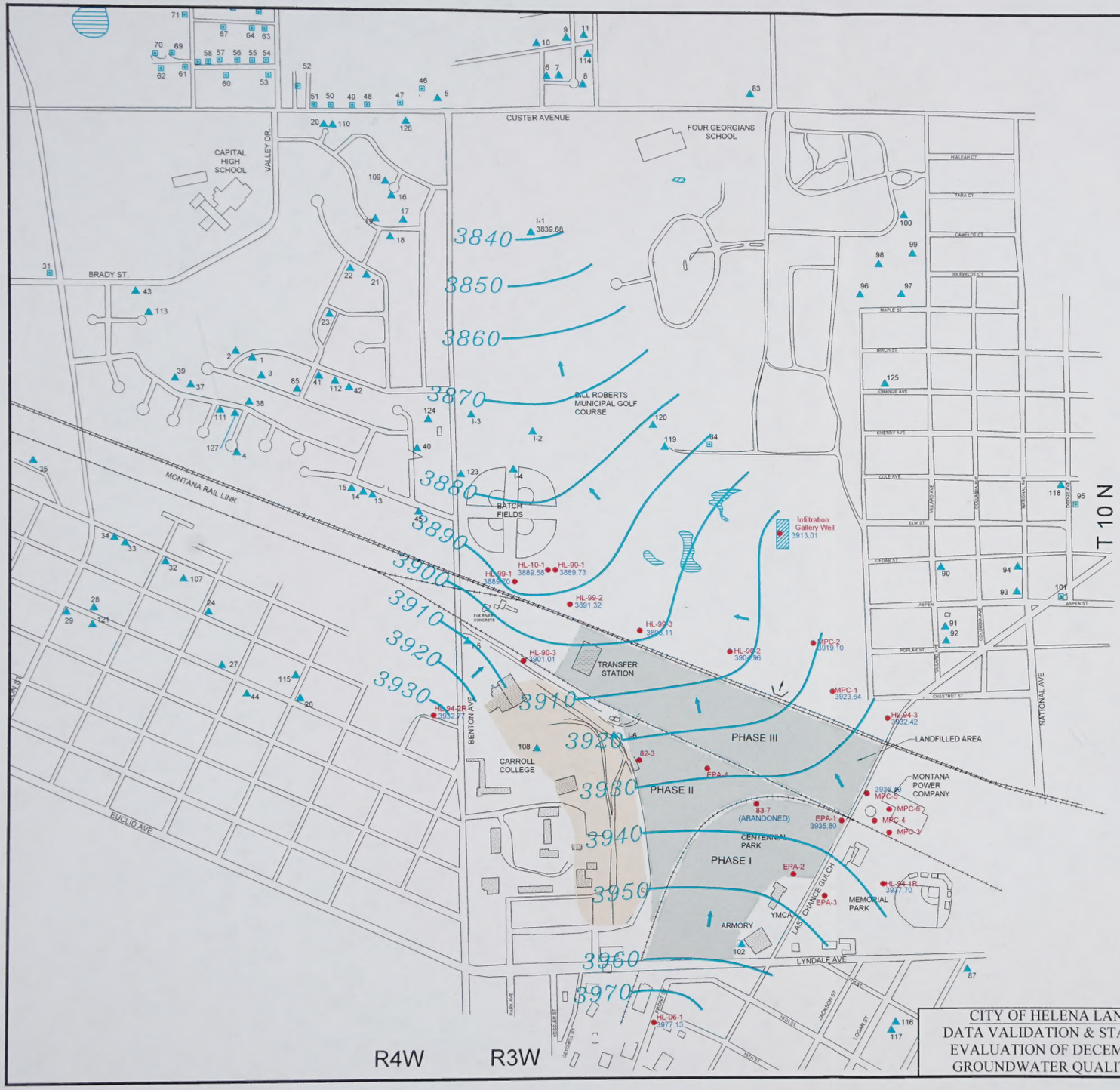

SITE CODE	DTWL	MPE	SWL
Dec-15			
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HL-90-1	52.75	3942.48	3889.73
HL-90-2	46.00	3950.96	3904.96
HL-90-3	57.28	3958.29	3901.01
HL-94-1R	56.34	3994.04	3937.70
HL-94-2R	34.87	3967.64	3932.77
HL-94-3	34.96	3967.38	3932.42
HL-99-1	53.45	3943.15	3889.70
HL-99-2	54.43	3945.75	3891.32
HL-99-3	49.94	3948.05	3898.11
INF. GALLE	5.88	3918.89	3913.01
I-1	59.91	3899.59	3839.68
MPC-1	22.44	3946.08	3923.64
MPC-2	16.99	3936.09	3919.10
MPC-5	53.65	3990.14	3936.49

NORTH

SCALE
0 (In Feet) 800

LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 ▣ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 3900 — POTENTIOMETRIC CONTOUR LINE
- → INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL EVALUATION OF DECEMBER 2015 GROUNDWATER QUALITY DATA

STUDY AREA AND DECEMBER 2015 POTENTIOMETRIC SURFACE

FIGURE
2-2

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2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in December 2015 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the December 2015 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report "Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill" (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0229 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.638 ft/day.

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
HL-06-1	0.03	0.0267	0.00320
HL-10-1	20	0.0106	0.849
HL-90-1	20	0.0103	0.822
HL-94-1R	2.8	0.0195	0.219
HL-99-1	10	0.0279	1.12
HL-99-2	20	0.0226	1.81
HL-99-3	20	0.0217	1.74
MPC-5	2.8	0.0187	0.210

3. SUMMARY OF DECEMBER 2015 DATA VALIDATION REPORT

Eight monitoring wells around the landfill and two domestic wells were included in the December 2015 sampling event. Static water levels (SWL) were obtained from eight additional monitoring wells, one irrigation well, and the infiltration gallery. The December 2015 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells EPA-1 (SWL only), EPA-2 (SWL only), HL-06-1, HL-10-1, HL-90-1, HL-90-2 (SWL only), HL-90-3 (SWL only), HL-94-1R, HL-94-2R (SWL only), HL-94-3 (SWL only), HL-99-1, HL-99-2, HL-99-3, MPC-1 (SWL only), MPC-2 (SWL only), MPC-5;
- Irrigation well I-1 (SWL only);
- Domestic wells 5, 16; and
- The infiltration gallery (SWL only).

The December analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells and volatile organics, semi-volatile organics, and halogenated organics for all domestic wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in December 2015 have been validated by the Hydrometrics' Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, two trip blanks, a rinsate blank, and standard internal laboratory QC samples. Methylene chloride was reported as above the reporting limit in both the D.I. blank and trip blank; however, no flagging of the data occurred. All field duplicate pair relative percent differences were within the required control limits except for mercury and trichloroethene, each of which resulted in four associated data results being flagged in the project database. The entire data validation report is included as Appendix A of this report.

3. SUMMARY OF DECEMBER 2015 DATA VALIDATION REPORT

Overall, the City of Helena Landfill data for December 2015 were deemed acceptable for the purposes of the project as outlined in the work plan.

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the December 2015 sample results for the monitoring wells around the landfill. The domestic wells are evaluated separately in Section 5. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called "background") water quality with summary statistics of downgradient concentrations for December 2015 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the December 2015 sampling event. The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that have recently exceeded their regulatory limits in downgradient wells. Data from all wells sampled during the December 2015 sampling event, which have historically shown PCE results above the detection limit and nitrate results above the MCL of 10 mg/L or with potentially increasing trends, were evaluated.

As noted in previous reports, new lower laboratory reporting limits (DEQ-7 RRV-based) were implemented in 2012 for certain dissolved metals and VOCs, compared with previous typical reporting limits for the Helena landfill groundwater samples. In many cases, the updated reporting limits are significantly lower than the historic limits. These reporting limit changes will impact the statistical analysis of these constituents since parameters which were previously reported as consistently below the detection limit may now be quantified at concentrations lower than the previous limit. For monitoring wells which contained metals results consistently below the detection limit prior to the June 2013 sampling event, this data was removed from the data set prior to statistical analysis. Until additional data points are obtained to develop a more robust data set at the new lower reporting limits, the power of the

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the December 2015 sample results for the monitoring wells around the landfill. The domestic wells are evaluated separately in Section 5. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called "background") water quality with summary statistics of downgradient concentrations for December 2015 and all samples to date;
2. Intra-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the December 2015 sampling event. The fourth analysis, temporal concentration plots, was performed for PCE and others, the only constituents that have recently exceeded their regulatory limits in downgradient wells. Data from all wells sampled during the December 2015 sampling event, which have historically shown VOC results above the detection limit and nitrate results above the MCL of 10 mg/L or with potentially interesting results, were evaluated.

As noted in previous reports, new lower laboratory reporting limits (DEQ-7 REV-based) were implemented in 2012 for certain dissolved metals and VOCs, compared with previous typical reporting limits for the Helena landfill groundwater samples. In many cases, the updated reporting limits are simply lower than the historic limits. These reporting limit changes will impact the statistical analyses of these constituents since parameters which were previously reported as consistently below the detection limit may now be quantified at concentrations lower than the previous limit. For monitoring wells which contained results consistently below the detection limit prior to the June 2013 sampling event, this data was removed from the data set prior to statistical analysis. Until additional data points are obtained to develop a more robust data set at the new lower reporting limits, the power of the

statistical tests to identify statistically significant exceedances and/or trends will be somewhat diminished.

4.1 DOWNGRADIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the December 2015 data and summary statistics in Tables 4-1, 4-2, and 4-3:

(a) For the December 2015 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (also called upgradient) wells: antimony, cadmium, nickel, selenium, 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, m+p xylenes, total xylenes, and toluene. Parameters detected in only downgradient wells include: lead, zinc, 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), trichloroethene (TCE), and trichlorofluoromethane.

(b) The parameters historically detected only in background wells (Table 4-3) are nickel, benzene, bromodichloromethane, and o-xylene. Parameters historically detected only in downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, TCE, and trichlorofluoromethane.

(c) Nitrate, iron, benzene, PCE, and cyanide were reported at concentrations exceeding MCL criteria in the December 2015 sampling event (Tables 4-1 and 4-2). The MCLs for benzene and cyanide were all exceeded in a single upgradient well (MPC-5); the MCL for nitrate was exceeded in two downgradient wells (HL-99-1 and HL-10-1) and two upgradient wells (HL-94-1R and MPC-5); the MCL for PCE was exceeded in four downgradient wells (HL-99-2, HL-99-3, HL-90-1 and HL-10-1); the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).

(d) Historically in these wells, nitrate, arsenic, iron, lead, benzene, PCE and cyanide have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCLs for benzene and arsenic have been exceeded in only upgradient wells; nitrate, iron, and

TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS FOR THE DECEMBER 2015 MONITORING EVENT

Parameter	Downgradient Wells					Upgradient Wells			GWPS [1]
	HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1	HL-06-1	HL-94-1R	MPC-5	
pH (s.u.)	7.2	7.3	7.3	7.3	7.1	7.1	7.4	7.1	NA
Specific Conductance (µmhos/cm)	1300	1030	994	1290	1350	1080	1250	2340	NA
Sulfate	159	130	144	131	166	91	111	333	NA
Chloride	80	48	52	119	85	44	58	22	NA
Nitrate+Nitrite as N	**10.7**	7.4	4.5	8.77	**10.3**	3.68	**13.2**	**16.8**	10
Antimony (Dissolved)	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0006	< 0.0005	< 0.0005	0.006
Arsenic (Dissolved)	0.002	0.002	0.002	0.002	0.001	0.003	0.002	0.004	0.010
Barium (Dissolved)	0.071	0.054	0.041	0.073	0.082	0.055	0.064	0.038	1.0
Cadmium (Dissolved)	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	0.00011	0.005
Copper (Dissolved)	0.007	0.003	0.004	< 0.002	0.002	< 0.002	< 0.002	0.003	1.3
Iron (Dissolved)	< 0.02	0.13	0.05	< 0.02	< 0.02	< 0.02	< 0.02	**0.83**	0.3 [2]
Lead (Dissolved)	0.0004	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	0.015
Mercury (Dissolved)	0.0000316	0.0000135	0.0000218	0.0000648	0.000168	< 0.000005	< 0.000005	0.0000089	0.002
Nickel (Dissolved)	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.009	0.10
Selenium (Dissolved)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.008	0.006	0.05
Zinc (Dissolved)	0.013	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	2.0
1,1,1-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0025	< 0.0005	< 0.0025	0.2
1,1-Dichloroethane	0.0011	0.004	0.0021	0.0019	0.0030	< 0.0005	< 0.0005	< 0.0025	NA
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	**1.24**	0.005
Bromodichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0022	< 0.0025	0.010
Chloroform	0.0016	0.0020	0.0024	0.00080	0.00064	0.0012	0.02	< 0.0025	0.07
Cis-1,2-Dichloroethene	0.0022	0.0016	0.0013	0.0017	0.0032	< 0.0005	< 0.0005	< 0.0025	0.07
Dichlorodifluoromethane	0.00071	0.0016	0.00084	< 0.0005	0.0013	< 0.0005	< 0.0005	< 0.0025	1.0
Total Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.111	10
M+P Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.049	10 [3]
O-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.062	10 [3]
Tetrachloroethene (PCE)	0.0043	**0.0070**	**0.0068**	**0.0054**	**0.0081**	< 0.0005	< 0.0005	< 0.0025	0.005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0027	1.0
Trichloroethene (TCE)	0.00110	0.0018	0.0011	0.0014	0.0023	< 0.0005	< 0.0005	< 0.0025	0.005
Trichlorofluoromethane	< 0.00050	0.00056	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0025	10
Cyanide (Total)	< 0.003	< 0.003	0.011	< 0.003	< 0.003	< 0.003	< 0.003	**1.94**	0.2
Chemical Oxygen Demand (COD)	2	6	5	6	6	3	8	35	NA

Concentrations are in mg/L, except as indicated.
NM = not measured

(1) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.
(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(3) GWPS is for Total Xylenes

Values in **bold** exceed the GWPS.

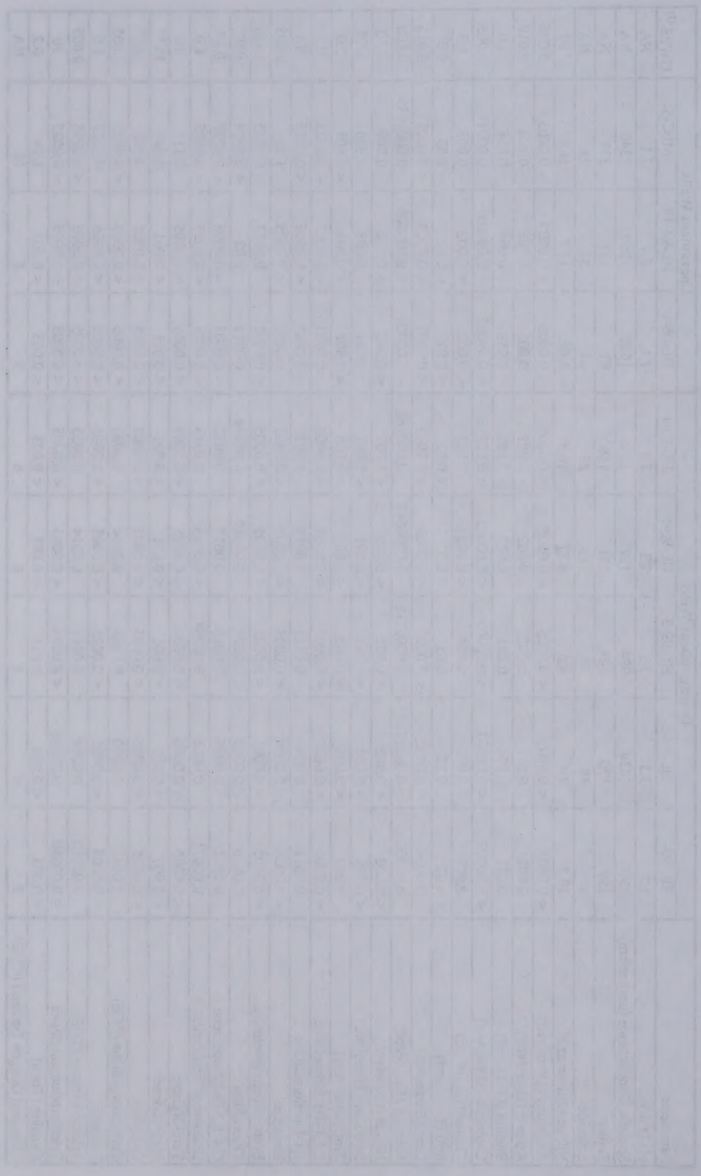


TABLE 4-2. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR THE DECEMBER 2015 SAMPLING EVENT

	December 2015 Downgradient Well Concentrations (mg/L)[1]						Comparison Values (mg/L)				
							Background / Upgradient Wells [2]				
Parameter	D.F. [3]	Min.	Mean [4]	Median	Max.	Max. Location	D.F. [3]	Mean [4]	Median	Max.	GWPS [5]
pH (s.u.)	5 / 5	7.1	7.24	7.3	7.3	HL-99-2	3 / 3	7.20	7.1	7.4	NA
Specific Conductance (µmhos/cm)	5 / 5	994	1193	1290	1350	HL-10-1	3 / 3	1557	1250	2340	NA
Sulfate	5 / 5	130	146	144	166	HL-10-1	3 / 3	178	111	333	NA
Chloride	5 / 5	48	77	80	119	HL-99-3	3 / 3	41	44	58	NA
Nitrate+Nitrite as N	5 / 5	4.5	8.33	8.77	**10.7**	HL-99-1	3 / 3	**11.23**	**13.2**	**16.8**	10
Antimony (Dissolved)	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.00053	< 0.0005	0.0006	0.006
Arsenic (Dissolved)	5 / 5	0.0010	0.0018	0.0020	0.002	HL-99-1	3 / 3	0.0030	0.003	0.004	0.010
Barium (Dissolved)	5 / 5	0.041	0.064	0.071	0.082	HL-10-1	3 / 3	0.052	0.055	0.064	1.0
Cadmium (Dissolved)	0 / 5	< 0.00003	< 0.000030	< 0.00003	< 0.00003	N/A	1 / 3	0.000057	< 0.00003	0.00011	0.005
Copper (Dissolved)	4 / 5	< 0.002	0.0036	0.003	0.007	HL-99-1	1 / 3	0.0023	< 0.002	0.003	1.3
Iron (Dissolved)	2 / 5	< 0.02	0.048	< 0.02	0.13	HL-99-2	1 / 3	**0.29**	< 0.02	**0.83**	0.3 [2]
Lead (Dissolved)	1 / 5	< 0.0003	0.00032	< 0.0003	0.0004	HL-99-1	0 / 3	< 0.00030	< 0.0003	< 0.0003	0.015
Mercury (Dissolved)	5 / 5	0.0000135	0.000060	0.0000316	0.000168	HL-10-1	1 / 3	0.000006	< 0.000005	0.0000089	0.002
Nickel (Dissolved)	0 / 5	< 0.002	< 0.002	< 0.002	< 0.002	N/A	1 / 3	0.0043	< 0.002	0.009	0.10
Selenium (Dissolved)	0 / 5	< 0.001	< 0.0010	< 0.001	< 0.001	N/A	3 / 3	0.0050	0.006	0.008	0.05
Zinc (Dissolved)	1 / 5	< 0.008	0.009	< 0.008	0.013	HL-99-1	0 / 3	< 0.008	< 0.008	< 0.008	2.0
1,1,1-Trichloroethane	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.00183	< 0.0025	0.0025	0.2
1,1-Dichloroethane	5 / 5	0.0011	0.0024	0.0021	0.004	HL-99-2	0 / 3	< 0.0012	< 0.0005	< 0.0025	NA
Benzene	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	**0.413667**	< 0.0005	**1.24**	0.005
Bromodichloromethane	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.0017	0.0022	0.0022	0.01
Chloroform	5 / 5	0.00064	0.0015	0.0016	0.0024	HL-99-3	2 / 3	0.0079	0.0025	0.02	0.07
Cis-1,2-Dichloroethene	5 / 5	0.0013	0.0020	0.0017	0.0032	HL-10-1	0 / 3	< 0.0012	< 0.0005	< 0.0025	0.07
Dichlorodifluoromethane	4 / 5	< 0.0005	0.0010	0.00084	0.0016	HL-99-2	0 / 3	< 0.0012	< 0.0005	< 0.0025	1
Total Xylene	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.037	< 0.0005	0.111	10
M+P Xylene	0 / 5	< 0.001	< 0.001	< 0.001	< 0.001	N/A	1 / 3	0.0170	< 0.001	0.0490	10 [3]
O-Xylene	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.021	< 0.0005	0.062	10 [3]
Tetrachloroethene (PCE)	5 / 5	0.0043	**0.0063**	**0.0068**	**0.0081**	HL-10-1	0 / 3	< 0.0012	< 0.0005	< 0.0025	0.005
Toluene	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.0012	< 0.0005	0.0027	0.005
Trichloroethene (TCE)	5 / 5	0.0011	0.0015	0.0014	0.0023	HL-10-1	0 / 3	< 0.0012	< 0.0005	< 0.0025	0.005
Trichlorofluoromethane	1 / 5	< 0.0005	0.00051	< 0.0005	0.00056	HL-99-2	0 / 3	< 0.0012	< 0.0005	< 0.0025	0.005
Cyanide (Total)	1 / 5	< 0.003	0.0046	< 0.003	0.011	HL-99-3	1 / 3	**0.65**	< 0.003	**1.9**	0.2
Chemical Oxygen Demand (COD)	5 / 5	2	5.0	6	6	HL-99-2	3 / 3	15.3	8	35	NA

(1) Downgradient wells are: HL-90-1, HL-99-1, HL-99-2, HL-99-3, HL-10-1.
(2) Background / Upgradient wells are: HL-06-1, HL-94-1R, MPC-5.
(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.
(4) Means calculated using the detection limit for non-detected sample results.
(5) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.
(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(7) GWPS is for Total Xylenes

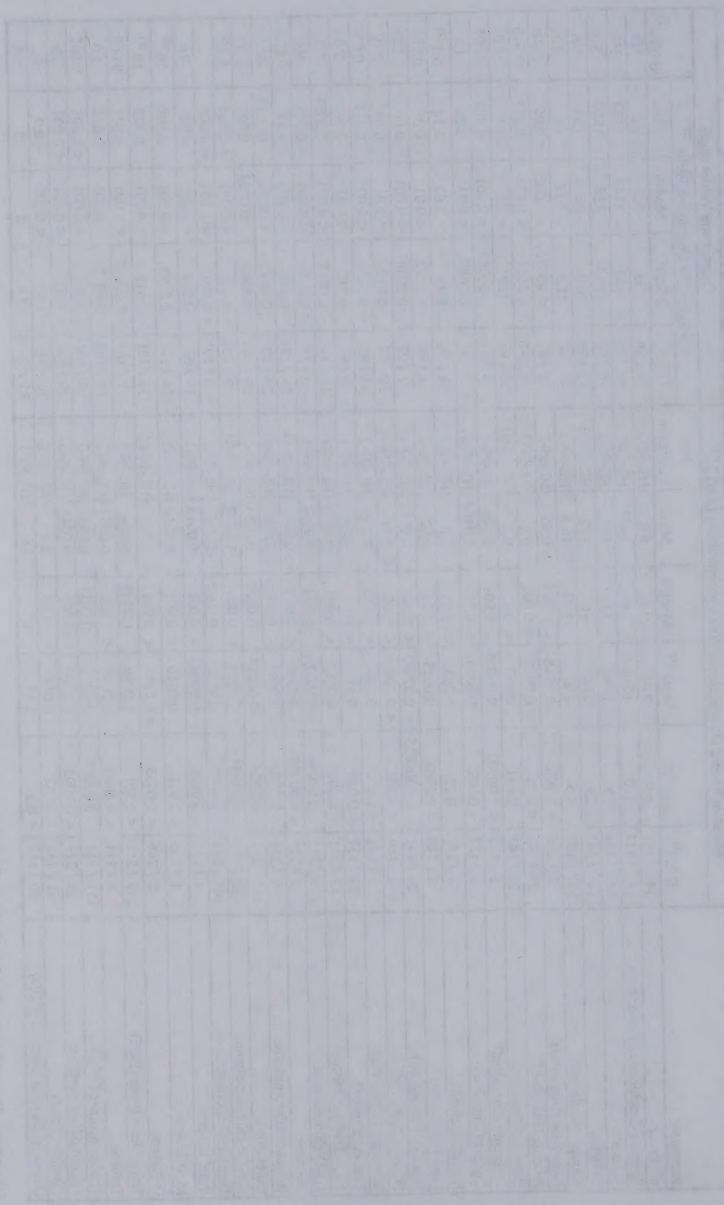
Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

TABLE 4-3. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR ALL SAMPLING EVENTS TO DATE

	Period of Record Downgradient Well Concentrations (mg/L) [1]						Comparison Values (mg/L)				
						Max.	Background / Upgradient Wells [2]				
Parameter	D.F. [3]	Min.	Mean [4]	Median	Max.	Location	D.F. [3]	Mean [4]	Median	Max.	GWPS [5]
pH (s.u.)	141 / 141	6.9	7.42	7.4	8.0	HL-99-3	96 / 96	7.33	7.3	8.0	NA
Specific Conductance (µmhos/cm)	137 / 137	710	1026	989	1470	HL-10-01	95 / 95	1667	1140	4170	NA
Sulfate	140 / 141	15	138.0	136	190	HL-99-1	96 / 96	370.4	138	1980	NA
Chloride	141 / 141	29	57.0	46	190	HL-10-01	95 / 96	30.3	26	120	NA
Nitrate+Nitrite as N	137 / 137	4.5	8.27	8.41	**16.6**	HL-99-3	96 / 96	**11.8**	7.18	**73**	10
Antimony (Dissolved)	3 / 136	< 0.0005	0.0018	< 0.005	< 0.05	HL-99-1	2 / 97	0.00055	< 0.005	< 0.05	0.006
Arsenic (Dissolved)	28 / 141	< 0.001	0.0045	< 0.005	0.01	HL-99-3	35 / 97	0.0051	< 0.005	**0.037**	0.010
Barium (Dissolved)	27 / 141	0.041	0.093	< 0.1	0.1	HL-10-01	20 / 97	0.091	< 0.1	0.1	1.0
Cadmium (Dissolved)	6 / 142	< 0.00003	0.00086	< 0.001	0.005	HL-90-1	9 / 97	0.00084	< 0.001	0.002	0.005
Copper (Dissolved)	9 / 137	< 0.002	0.0086	< 0.01	0.010	HL-10-01	7 / 97	0.0088	< 0.01	0.02	1.3
Iron (Dissolved)	44 / 141	< 0.02	0.083	< 0.03	**1.0**	HL-99-1	38 / 96	**0.49**	< 0.03	**3.14**	0.3 [2]
Lead (Dissolved)	3 / 142	< 0.0003	0.0083	< 0.01	**0.02**	HL-90-1	1 / 97	0.0082	< 0.01	0.01	0.015
Mercury (Dissolved)	26 / 141	0.0000055	0.00083	< 0.001	0.0010	HL-10-01	7 / 97	0.00081	< 0.001	0.0010	0.002
Nickel (Dissolved)	0 / 136	< 0.002	< 0.008	< 0.01	< 0.01	HL-10-01	30 / 97	0.010	< 0.01	0.05	0.10
Selenium (Dissolved)	9 / 141	< 0.001	0.0043	< 0.005	0.006	HL-99-2	44 / 97	0.0054	< 0.005	0.011	0.05
Zinc (Dissolved)	24 / 137	< 0.008	0.012	< 0.01	0.09	HL-90-1	8 / 97	0.010	< 0.01	0.02	2.0
1,1,1-Trichloroethane	43 / 211	< 0.0002	0.0013	< 0.001	0.0074	HL-90-1	19 / 101	0.0013	< 0.001	0.0057	0.2
1,1-Dichloroethane	173 / 211	0.00068	0.0021	0.002	0.0052	HL-99-3	0 / 101	< 0.001	< 0.001	< 0.001	NA
Benzene	0 / 211	< 0.00005	< 0.0009	< 0.001	< 0.001	HL-10-01	35 / 101	**0.095**	< 0.001	**4.65**	0.005
Bromodichloromethane	0 / 211	< 0.0005	< 0.0009	< 0.001	< 0.001	HL-10-01	20 / 101	0.0013	< 0.001	0.0048	0.01
Chloroform	185 / 211	0.0006	0.00224	0.0021	0.0055	HL-90-1	76 / 101	0.0069	0.0033	0.037	0.07
Cis-1,2-Dichloroethene	85 / 206	0.00051	0.0013	< 0.001	0.0032	HL-10-01	0 / 101	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	147 / 211	< 0.0005	0.0018	0.0013	0.015	HL-90-1	0 / 101	< 0.001	< 0.001	< 0.001	1
Total Xylene	1 / 112	< 0.0005	0.00089	< 0.001	0.0013	HL-90-1	19 / 63	0.029	< 0.001	0.93	10
M+P Xylene	1 / 205	< 0.001	0.0010	< 0.001	0.0010	HL-99-2	34 / 101	0.0095	< 0.001	0.508	10 [3]
O-Xylene	0 / 206	< 0.0005	< 0.001	< 0.001	< 0.001	HL-10-01	36 / 101	0.013	< 0.001	0.422	10 [3]
Tetrachloroethene (PCE)	209 / 211	< 0.001	**0.0068**	**0.0059**	**0.024**	HL-99-3	1 / 101	0.00092	< 0.001	0.001	0.005
Toluene	4 / 211	< 0.0005	0.0010	< 0.001	0.0063	HL-99-3	10 / 101	0.0012	< 0.001	0.015	1.0
Trichloroethene (TCE)	131 / 211	0.00067	0.0013	0.0011	0.0032	HL-99-3	0 / 101	< 0.001	< 0.001	< 0.001	0.005
Trichlorofluoromethane	28 / 211	< 0.0005	0.0010	< 0.001	0.0044	HL-99-3	0 / 101	< 0.001	< 0.001	< 0.001	10
Cyanide (Total)	51 / 141	< 0.003	0.014	< 0.005	**0.4**	HL-99-2	36 / 97	**1.85**	< 0.005	**10.9**	0.2
Chemical Oxygen Demand (COD)	90 / 140	< 0.3	3.17	2	25	HL-99-3	85 / 96	17.6	8	75	NA

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-99-1, HL-99-2, HL-99-3.
(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1, HL-94-1R.
(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.
(4) Means calculated using the detection limit for non-detected sample results.
(5) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.
(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(7) GWPS is for Total Xylenes

Values in **bold** exceed the GWPS. Underlined values exceed the maximum background/upgradient concentration.



cyanide have exceeded their MCLs in both upgradient and downgradient wells; and the MCLs for lead and PCE have been exceeded in only downgradient wells.

(e) Nitrate was detected in all of the December 2015 samples. The MCL of 10.0 mg/L was exceeded in four samples; two collected in upgradient wells HL-94-1R and MPC-5 and two in downgradient wells HL-99-1 and HL-10-1. Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 16.8 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse effects became apparent. However, nitrate levels in downgradient wells have shown a corresponding increase over time.

(f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). The recent implementation of lower detection limits has increased the frequency of metals detections in all wells. Arsenic and barium were detected in all samples both upgradient and downgradient; cadmium and nickel were detected only in upgradient well MPC-5; copper was detected in downgradient wells HL-99-1, HL-99-2, HL-99-3, and HL-10-1 and upgradient well MPC-5; iron was detected in downgradient wells HL-99-2 and HL-99-3 and upgradient well MPC-5; lead and zinc were detected only in downgradient well HL-99-1; mercury was detected in all five downgradient wells and upgradient well MPC-5; and selenium was detected in all three upgradient wells during December 2015 monitoring (Table 4-1). The detected metal concentrations were all at or near their detection limits except for barium in all wells, ranging from 0.038 mg/L to 0.082 mg/L compared with a detection limit of 0.003 mg/L; mercury in all downgradient wells ranging from 0.0000135 mg/L to 0.000168 mg/L compared to a detection limit of 0.000005 mg/L; and iron in downgradient well HL-99-2 (0.13 mg/L) and upgradient well MPC-5 (0.83 mg/L) compared to a detection limit of 0.02 mg/L. All detections were below the primary MCL values for their respective parameters. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as

taste, odor and staining rather than human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through December 2015).

(g) During the December 2015 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane). PCE exceeded the MCL in downgradient wells HL-99-2, HL-99-3, HL-90-1, and HL-10-1. The parameters 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, m+p xylenes, total xylenes, and toluene were detected only in background wells; benzene was the only VOC to exceed its MCL in an upgradient well (MPC-5). Chloroform was the only VOC detected in samples from both downgradient and background wells; all detections of chloroform were well below the MCL of 0.07 mg/L.

(h) Cyanide was detected in a single downgradient well (HL-99-3) and one upgradient well (MPC-5) during the December 2015 sampling event. The downgradient detection was well below the MCL of 0.2 mg/L; however, upgradient well MPC-5 far exceeded the MCL with a concentration of 1.94 mg/L.

Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through December 2015) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

4.2 INTER-WELL PREDICTION INTERVAL ANALYSES

Inter-well prediction interval analyses were used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the December 2015

sampling event). Combining all historical data for the background wells, either the Shapiro-Wilks test of normality (n<50) or the Shapiro-Francia Test of Normality (N>50) was performed for each parameter to determine the distribution of the background data. Inter-well parametric prediction intervals were used when the background data were normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at one half the detection limit for all parametric analyses. Results of the prediction interval test are summarized in Table 4-4. Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, chloride, copper, lead, mercury, zinc, 1,1-dichloroethane, cis-1,2-dichloroethane, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane have statistically greater concentrations in downgradient wells than upgradient wells.

4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the December 2015 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The results of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

Chloride is showing an increasing trend in well HL-90-1; there is no groundwater protection standard for chloride. There are no statistical trends in copper, lead, mercury or zinc in any of the downgradient wells. 1,1-dichloroethane is showing an increasing trend in downgradient wells HL-99-2 and HL-10-1 and a decreasing trend in well HL-90-1; this compound is a breakdown product of 1,1,1-trichloroethane, historically found in both upgradient and downgradient wells. Cis-1,2-dichloroethane is showing an increasing trend in

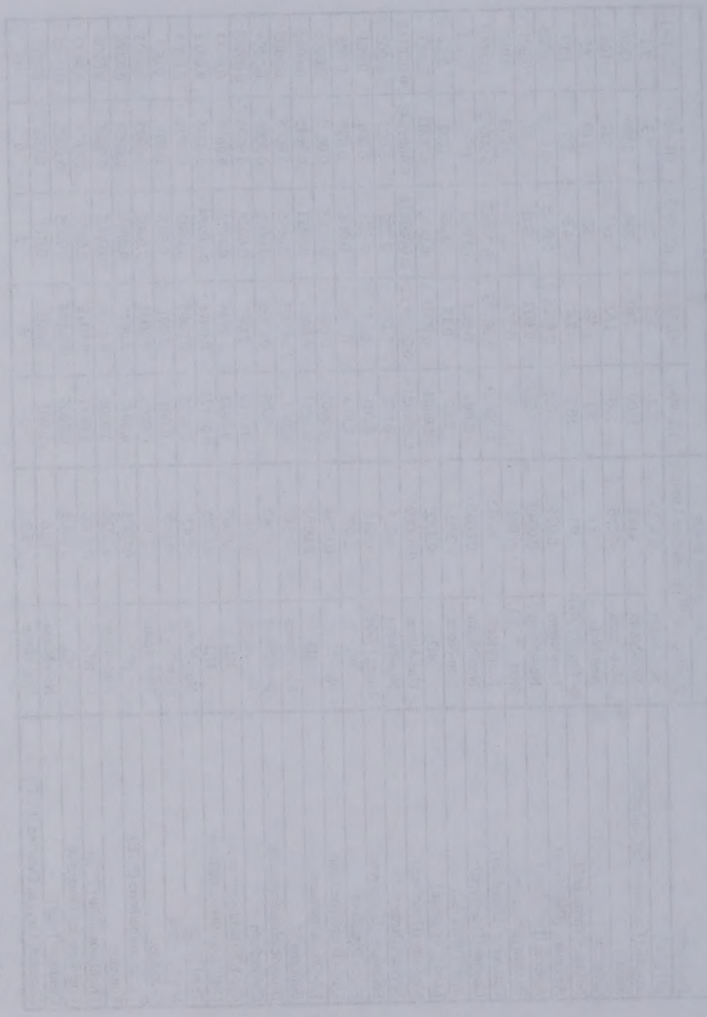
TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

Parameter	Background Wells						
	Distribution [1]	Prediction Limit [2]	HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1
pH (s.u.)	Non-Norm	6.9-7.9	7.2	7.3	7.3	7.3	7.1
Specific Conductance (µmhos/cm)	Non-Norm	4113	1300	1030	994	1290	1350
Sulfate	Non-Norm	1866	159	130	144	131	166
Chloride	Non-Norm	87	80	48	52	**119**	85
Nitrate+Nitrite as N	ln-Norm (95%)	93	10.7	7.4	4.5	8.77	10.3
Antimony (Dissolved)	Non-Norm	0.025	0.0005	0.0005	0.0005	0.0005	0.0005
Arsenic (Dissolved)	Non-Norm	0.0040	0.002	0.002	0.002	0.002	0.001
Barium (Dissolved)	Norm (95%)	0.098	0.071	0.054	0.041	0.073	0.082
Cadmium (Dissolved)	Non-Norm	0.00012	0.00003	0.00003	0.00003	0.00003	0.00003
Copper (Dissolved)	Non-Norm	0.0030	**0.007**	0.003	**0.004**	0.002	0.002
Iron (Dissolved)	Non-Norm	2.95	0.02	0.13	0.05	0.02	0.02
Lead (Dissolved)	ND	0.0003	**0.0004**	0.0003	0.0003	0.0003	0.0003
Mercury (Dissolved)	Non-Norm	0.000030	**0.0000316**	0.0000135	0.0000218	**0.0000648**	**0.000168**
Nickel (Dissolved)	Non-Norm	0.013	0.002	0.002	0.002	0.002	0.002
Selenium (Dissolved)	Norm (99%)	0.016	0.001	0.001	0.001	0.001	0.001
Zinc (Dissolved)	ND	0.008	**0.013**	0.008	0.008	0.008	0.008
1,1,1-Trichloroethane	Non-Norm	0.0054	0.0005	0.0005	0.0005	0.0005	0.0005
1,1-Dichloroethane	ND	0.0005	**0.0011**	**0.0040**	**0.0021**	**0.0019**	**0.0030**
Benzene	Non-Norm	1.38	0.0005	0.0005	0.0005	0.0005	0.0005
Bromodichloromethane	Non-Norm	0.0042	0.0005	0.0005	0.0005	0.0005	0.0005
Chloroform	Non-Norm	0.036	0.0016	0.002	0.0024	0.0008	0.00064
Cis-1,2-Dichloroethene	ND	0.0005	**0.0022**	**0.0016**	**0.0013**	**0.0017**	**0.0032**
Dichlorodifluoromethane	ND	0.0005	**0.00071**	**0.0016**	**0.00084**	0.0005	**0.0013**
Total Xylene	Non-Norm	0.47	0.0005	0.0005	0.0005	0.0005	0.0005
M+P Xylene	Non-Norm	0.049	0.001	0.001	0.001	0.001	0.001
O-Xylene	Non-Norm	0.17	0.0005	0.0005	0.0005	0.0005	0.0005
Tetrachloroethene (PCE)	ND	0.0005	**0.0043**	**0.0070**	**0.0068**	**0.0054**	**0.0081**
Toluene	Non-Norm	0.0030	0.0005	0.0005	0.0005	0.0005	0.0005
Trichloroethene (TCE)	ND	0.0005	**0.0011**	**0.0018**	**0.0011**	**0.0014**	**0.0023**
Trichlorofluoromethane	ND	0.0005	0.0005	**0.00056**	0.0005	0.0005	0.0005
Cyanide (Total)	Non-Norm	10.6	0.003	0.003	0.011	0.003	0.003
Chemical Oxygen Demand (COD)	Non-Norm	69.3	2	6	5	6	6

(1) Normality was calculated using the Shapiro-Francia test. (Non-detects replaced with 1/2 detection limit.)
Norm (X%) = data normally distributed at X% level of significance.
ln-Norm (X%) = data ln-normally distributed at X% level of significance.
Non-Norm = data not normally or ln-normally distributed at 95% or 99% level of significance.
ND = all background data below detection limits. Value shown is the detection limit.

(2) Inter-well prediction limits calculated as follows with non-detects replaced with 1/2 detection limit:
Normal or ln-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)
Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)
ND: any detectable concentrations in compliance wells are considered significant.

Bold values indicate statistically significant results.



wells HL-99-2, HL-99-3, HL-90-1, and HL-10-1; this compound is formed as a breakdown product of TCE and PCE. Dichlorodifluoromethane is showing a decreasing trend in downgradient well HL-99-3. PCE is showing an increasing trend in well HL-10-1, but decreasing trends in wells HL-99-1, HL-99-3, and HL-90-1. TCE is showing an increasing trend in wells HL-99-1, HL-99-2, and HL-10-1, but a decreasing trend in HL-90-1. PCE and TCE are common industrial solvents.

TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES

Parameter	HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1
Chloride				Increasing	
Copper	No Trend		No Trend		
Lead	No Trend				
Mercury	No Trend			NA	No Trend
Zinc	No Trend				
1,1-Dichloroethane	No Trend	Increasing	No Trend	Decreasing	Increasing
Cis-1,2-Dichloroethane	No Trend	Increasing	Increasing	Increasing	Increasing
Dichlorodifluoromethane	No Trend	No Trend	Decreasing		No Trend
Tetrachloroethene (PCE)	Decreasing	No Trend	Decreasing	Decreasing	Increasing
Trichloroethene (TCE)	Increasing	Increasing	No Trend	Decreasing	Increasing
Trichlorofluoromethane		No Trend			

* Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed. NA = not enough data was available at lower detection limit to perform a trend analysis.

4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2, and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events

wells BL-99-2, BL-99-3, DL-99-1, and BL-99-1; this compound is formed as a breakdown product of TCE and PCE. Dechlorination conditions is showing a decreasing trend in downgradient well BL-99-3. TCE is showing an increasing trend in well BL-10-1, but decreasing trends in wells BL-99-1, BL-99-2, and BL-99-1. TCE is showing an increasing trend in wells DL-99-1, BL-99-2, and BL-10-1, but a decreasing trend in BL-99-1. PCE and TCE are common industrial solvents.

TABLE 4-5. EVIDENCE OF NATURAL ATTENUATION

Parameter	BL-99-2	BL-99-3	DL-99-1	BL-99-1	BL-10-1
Chlorate					
Oxygen					
Iron					
Nitrate					
Methane					
Ethane					
Ethene					
Chloride					
Alkalinity					
Dissolved Organic Carbon (DOC)					
Temperature					

* Parameter does not have decreasing concentrations or the magnitude between background and treatment zone is not significant. Data may not be available or data may not be collected.

4.4 TECHNICAL CONSIDERATIONS

This section discusses considerations for design and future actions. The following considerations were used in developing monitoring wells. TCE was also the focus of the Corrective Measures Assessment for the Sheffield Orchard, 1993).

Based on the above considerations of TCE in groundwater, well BL-99-1, the only existing downgradient monitoring well in the treated area (Blasland, 1994). This location is also the only monitoring wells BL-99-1, BL-99-2, and BL-99-3 to intercept TCE leaving the landfill, and nearing the water to receive VOCs prior to land application on Bill Rogers Golf Course. These wells have been included in groundwater monitoring events.

along with compliance wells HL-90-1 and HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past ten years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-99-2, HL-99-3, HL-90-1, and HL-10-1 for December 2015. Historically, the PCE concentrations in pumping wells HL-99-1, HL-99-2, and HL-99-3 have shown seasonal fluctuations and decreasing trends over the last several years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0070 mg/L after. Due to low water levels in well HL-90-1, a new, deeper well HL-10-1 was installed near HL-90-1. PCE concentrations in this new well range from 0.006 mg/L to 0.0082 mg/L from June 2010 to the December 2015 sampling event, within historical range of HL-90-1 values. An increasing trend is indicated by statistical analysis (see Section 4.3), but that trend is less apparent on the graph. Extraction wells HL-99-1 and HL-99-3 immediately upgradient of compliance well HL-10-1 are both showing statistically decreasing PCE trends.

Nitrate concentrations in all downgradient monitoring wells and upgradient well MPC-5 are shown on Figure 4-2. The concentrations of nitrate in downgradient wells HL-90-1, HL-99-2, and HL-99-3 have shown no trend or slightly decreasing trends for the last ten years. Wells HL-99-1 and HL-10-1 have shown a slightly increasing nitrate trend and are currently just over the MCL at 10.3 mg/L and 10.7 mg/L, respectively.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well with the December 2015 concentration at 16.8 mg/L. Upgradient well HL-94-1R has also shown a generally increasing nitrate trend over the last ten years reaching a maximum of 20.0 mg/L in June 2015 and is currently at 13.2 mg/L.

along with compliance wells HL-99-1 and HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past ten years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-99-2, HL-99-3, HL-99-1, and HL-10-1 for December 2015. Historically, the PCE concentrations in pumping wells HL-99-1, HL-99-2, and HL-99-3 have shown seasonal fluctuations and decreasing trends over the last several years. Compliance well HL-99-1 has shown definite improvement since the installation of the groundwater extraction system in June 2009, averaging 0.0146 mg/L before the extraction system and 0.0030 mg/L after. Due to low water levels in well HL-99-1, a new, deeper well HL-10-1 was installed near HL-99-1. PCE concentrations in this new well range from 0.005 mg/L to 0.0052 mg/L from June 2010 to the December 2015 sampling event, within historical range of HL-99-1 values. An increasing trend is indicated by statistical analysis (see Section 4.3), but that trend is less apparent on the graph. Extraction wells HL-99-1 and HL-99-3 immediately upgradient of compliance well HL-10-1 are both showing statistically decreasing PCE trends.

Nitrate concentrations in all downgradient monitoring wells and upgradient well MPC-5 are shown on Figure 4-2. The concentrations of nitrate in downgradient wells HL-99-1, HL-99-2, and HL-99-3 have shown no trend or slightly decreasing trends for the last ten years. Wells HL-99-1 and HL-10-1 have shown a slightly increasing nitrate trend and are currently just over the MCL at 10.3 mg/L and 10.7 mg/L, respectively.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 23.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well with the December 2015 concentration at 18.8 mg/L. Upgradient well HL-99-4R has also shown a generally increasing nitrate trend over the last ten years reaching a maximum of 20.0 mg/L in June 2015 and is currently at 13.2 mg/L.

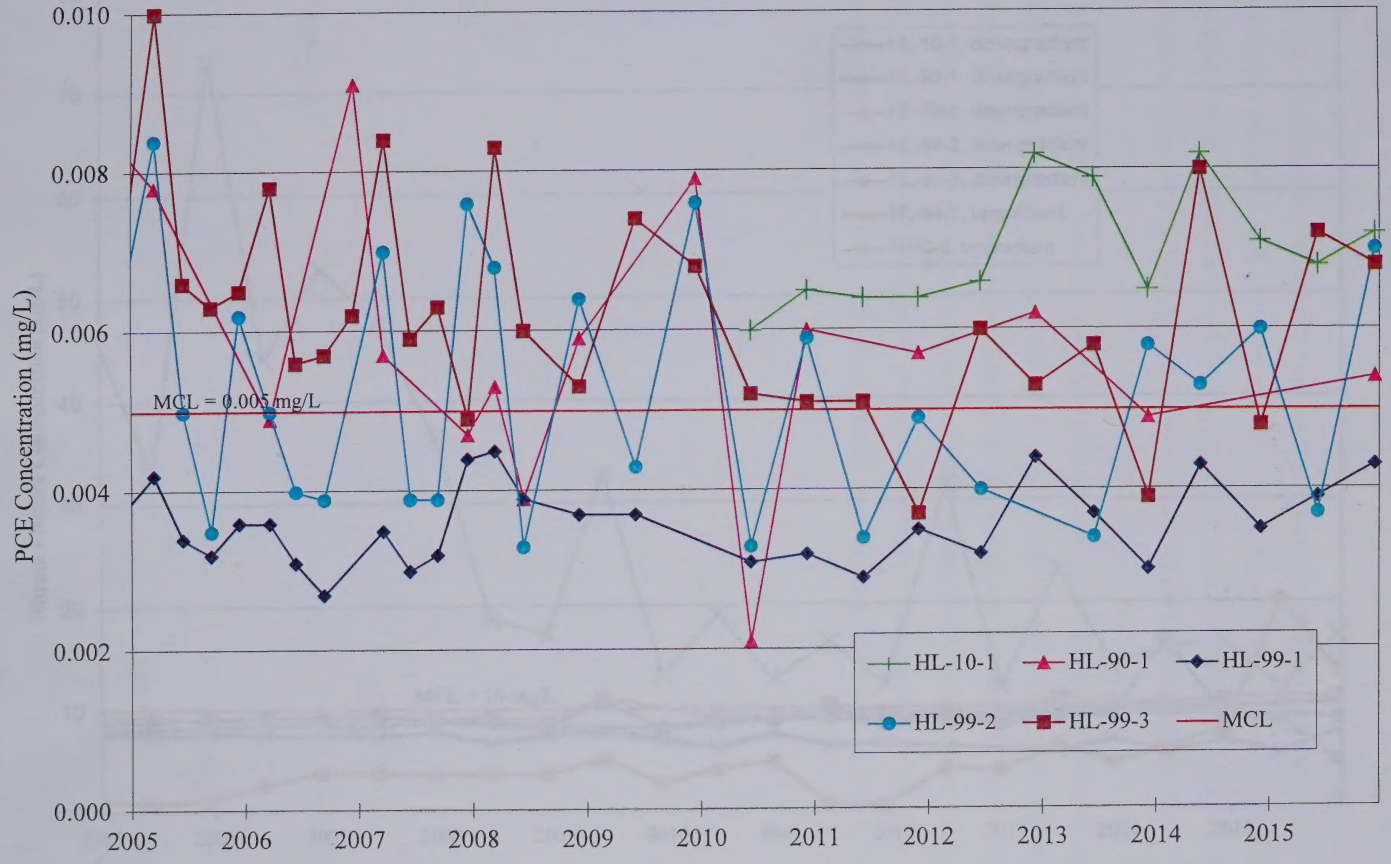


Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells

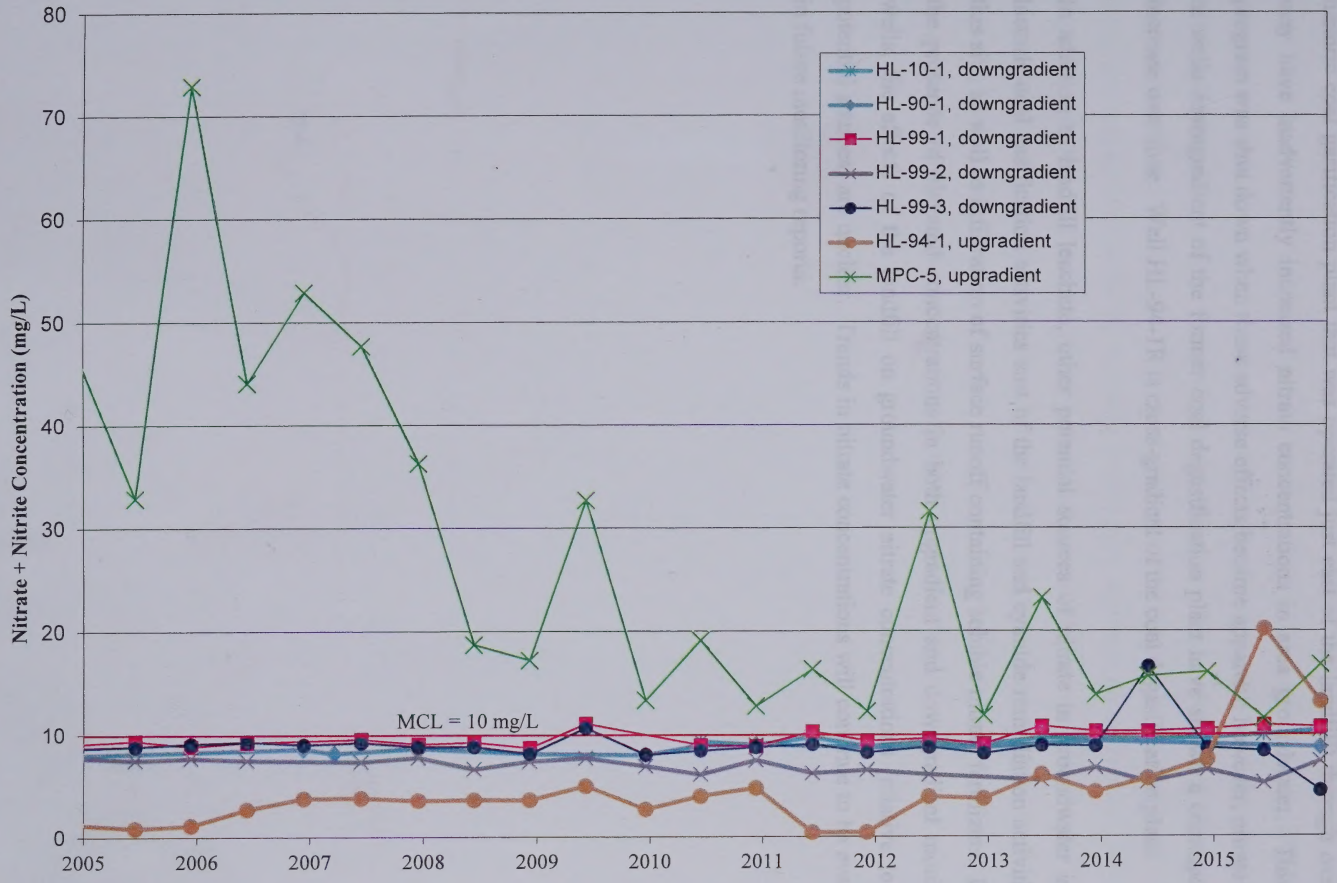


Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells

Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse effects became apparent; however, nitrate levels in wells downgradient of the former coal degasification plant have shown a corresponding increase over time. Well HL-94-1R is cross-gradient of the coal degasification plant.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

5. DOMESTIC WELL DATA EVALUATION

Two domestic wells were also included in the December 2015 sampling event. For well 5, the only concentrations of VOCs reported above the detection limit were for chloroform, PCE, and TCE; all detections were below their respective MCLs. PCE concentrations over the last ten years for domestic well 5 are shown on Figure 5-1 and show an overall decreasing trend. For well 16, the only VOCs with reported concentrations above the detection limit were 1,1-dichloroethane, chloroform, dichlorodifluoromethane, and PCE; all detections were below their respective MCLs. PCE concentrations for this well are shown on Figure 5-1 and show an increasing trend. All wells in these areas are used only for irrigation, and residential homes have been connected to the City water supply.

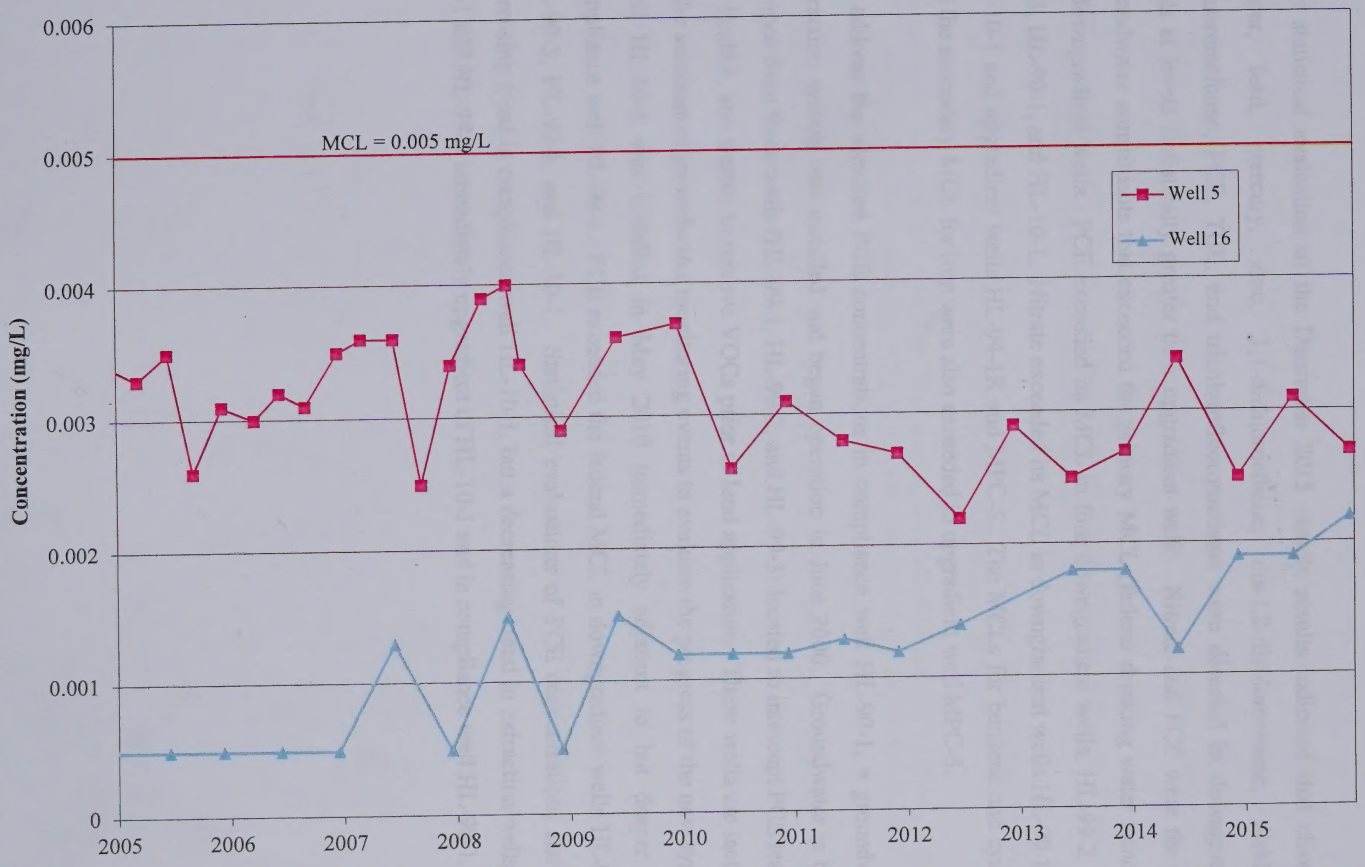


Figure 5-1. Temporal Trends in PCE Concentrations in Domestic Wells

6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the December 2015 sample results indicated that chloride, copper, lead, mercury, zinc, 1,1-dichloroethene, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane were detected in downgradient wells at levels statistically greater than upgradient wells. Nitrate and PCE were the only groundwater constituents that exceeded the primary MCL (federal drinking water standard) in downgradient wells. PCE exceeded its MCL in four downgradient wells, HL-99-2, HL-99-3, HL-90-1, and HL-10-1. Nitrate exceeded its MCL in downgradient wells HL-99-1 and HL-10-1 and upgradient wells HL-94-1R and MPC-5. The MCLs for benzene and cyanide and the secondary MCL for iron were also exceeded in upgradient well MPC-5.

To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2, and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Well HL-10-1 was installed in May 2010 immediately adjacent to but deeper than compliance well HL-90-1. PCE exceeded the federal MCL in downgradient wells HL-99-2, HL-99-3, HL-90-1, and HL-10-1. Statistical evaluations of PCE concentrations show an increasing trend in compliance well HL-10-1, but a decreasing trend in extraction wells HL-99-1 and HL-99-3 immediately upgradient of HL-10-1 and in compliance well HL-90-1.

7. REFERENCES

EPA, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities – Interim Final Guidance, EPA/530-SW-89-026, February 1989.

EPA, 1992. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities – Addendum to Interim Final Guidance, Draft, Office of Solid Waste, Permits and State Programs Division, July 1992.

Hydrometrics, Inc., 1995. Corrective Measures Assessment, City of Helena Landfill, Helena, Montana, Prepared for City of Helena, February 1995.

Hydrometrics, Inc., 1999a. Evaluation of Groundwater Extraction Remediation Alternatives at the Helena Landfill, Prepared for the City of Helena, August 1999.

Hydrometrics, Inc., 1999b. Contract Documents and Specifications for Helena Landfill Groundwater Extraction City, City of Helena Project No. 98-55, Prepared for City of Helena, September 1999.

Hydrometrics, Inc., 2008. Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities, Prepared for City of Helena, March 2008.

APPENDIX A

DATA VALIDATION REPORT

DATA VALIDATION REPORT

CITY OF HELENA LANDFILL

Groundwater Samples Collected in

December 2015
(Semi-Annual Sampling)

Prepared by
Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

FEBRUARY 2016

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GLOSSARY OF TERMS

CCB.....Continuing Calibration Blank

CCV .....Continuing Calibration Verification

CLP .....Contract Laboratory Program

CRDL.....Contract Required Detection Limit

FAA .....Flame Atomic Absorption

GFAA.....Graphite Furnace Atomic Absorption

HGAA.....Hydride Generation Atomic Absorption

ICB.....Initial Calibration Blank

ICP .....Inductively Coupled Plasma

ICV.....Initial Calibration Verification

IDL.....Instrument Detection Limit

LCS .....Laboratory Control Sample

MSA.....Method of Standard Additions

PB.....Preparation Blank

PRDL .....Project Required Detection Limit

QAPP .....Quality Assurance Project Plan

QC.....Quality Control

RPD.....Relative Percent Difference

RSD.....Relative Standard Deviation

SOW.....Statement of Work

TDS .....Total Dissolved Solids

SUMMARY

Laboratory analysis for groundwater samples collected for the December 2015 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

Violations involving field quality control samples:

- In field duplicate samples, HL-1512-103/104 (HL-10-01); one exceedance occurred for mercury and trichloroethene each resulting in four associated results being flagged.

- In field rinsate blank sample, HL-1512-107 and field di blank sample HL-1512-106, one exceedance occurred in each for methylene chloride resulting in no associated results being flagged in the project database.

- It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book or sampling forms.

Violations involving laboratory quality control samples:

- In the QA/QC Summary Reports provided by Energy Laboratories, there were several QA/QC exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.

- It should be noted that the reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis.

- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.

- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 99 percent of the field quality control sample results were within control limits and 99 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; and a historical comparison is in Table 2; and a summary of flagged data is in Table 3. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field Notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

DATA VALIDATION REPORT

1. INTRODUCTION

This validation applies to organic and inorganic analyses for 25 water samples collected for the City of Helena Landfill semi-annual monitoring project during the December 2015 sampling event. The total number of samples included: one field duplicate, two field blanks (DI and Rinsate), two trip blanks, ten non-QC water samples and ten field observations.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

SITE CODE	SAMPLE NUMBER	WATER LEVEL	FIELD PARAMETERS [1]	METALS AND COMMONS [2]	VOLATILES METHOD 8260 [3]
#5	HL-1512-100		X		X
HL-94-1R	HL-1512-101	X	X	X	X
HL-06-1	HL-1512-102	X	X	X	X
HL-10-01	HL-1512-103	X	X	X	X
HL-10-01 DUP	HL-1512-104			X	X
HL-90-1	HL-1512-105	X	X	X	X
Rinsate Blank	HL-1512-106			X	X
D.I. Blank	HL-1512-107			X	X
HL-99-1	HL-1512-108	X	X	X	X
HL-99-2	HL-1512-109	X	X	X	X
HL-99-3	HL-1512-110	X	X	X	X
MPC-5	HL-1512-111	X	X	X	X
#16	HL-1512-112		X		X
TRIP BLANK	HL-1512-113				X
TRIP BLANK	HL-1512-114				X
EPA-1	HL-1512-115	X			
HL-90-2	HL-1512-116	X			
HL-90-3	HL-1512-117	X			
HL-94-2R	HL-1512-118	X			
HL-94-3	HL-1512-119	X			
I-1	HL-1512-120	X			
INF GALLERY	HL-1512-121	X			
MPC-1	HL-1512-122	X			
MPC-2	HL-1512-123	X			
EPA-2	HL-1512-124	X			

1.) Field parameters include pH, SC, and water temperature.
2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.
3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:
  (Check all that apply)
  _X_ EPA CLP National Functional Guidelines for Inorganics Data Review
  _X_ EPA CLP National Functional Guidelines for Organic Data Review
  _X_ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)

- Overall level of validation:
  ___ Contract Laboratory Program (CLP)
  _X_ Standard (see following Notes)
  ___ Visual

  Notes: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.
  _X_ Yes (see following notes)
  ____No

- All documentation of field procedures was provided as required.
  _X_ Yes
  ___No

- Consistency with project requirements
  Sampling was completed in order as stated in the SAP.
  _X_ Yes (see following Notes)
  ____No

  Notes: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

3. FIELD QUALITY CONTROL SAMPLES

- **Field blanks**
  Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.
  DI, trip, rinsate, or any other field blanks have been carried out at the proper frequency.
  _X_ Yes
  ___No

Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

___Yes
_X_No (see the following notes)

Notes: In field rinsate blank sample, HL-1512-107 and field di blank sample HL-1512-106, one exceedance occurred in each for methylene chloride resulting in no associated results being flagged in the project database.

- **Field duplicates**

  Field duplicates have been collected at the proper frequency.

  _X_Yes
  ___No

  Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within ± the PRDL for water matrix, within ±2 times the PRDL for soil matrix.

  ___Yes
  _X_No (see the following notes)

  Notes: In field duplicate samples, HL-1512-103/104 (HL-10-01); one exceedance occurred for mercury and trichloroethene each resulting in four associated results being flagged.

- **Field standards**

  Field standards were sent at the proper frequency

  ___Yes
  ___No
  _X_NA - Not required by the work plan.

4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

  ___ CLP-SOW
  _X_ SW-846
  _X_ Methods for Chemical Analysis of Water and Wastes
  ___ XRF Standard Operating Procedures
  ___ Other

- **Samples were received by the laboratory at the proper temperature**

  _X_Yes
  ___No

- **Holding times met**

  ___Yes
  _X_No (see the following Notes)

  Notes: Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately",

but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances in the database.

- **Consistency with project requirements**

  Analyses were carried out as requested.
  _X_Yes (see following Notes)
  ____No

  Project specified methods were used.
  _X_Yes (see following Notes)
  ____No

  Notes: Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.

5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).
  _X_Yes (see following Notes)
  ____No

  Notes: The reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis.

6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

  Preparation/Method blanks were prepared and analyzed at the required frequency.
  _X_Yes
  ___No

  All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).
  _X_Yes
  ___No

7. LABORATORY BLANK SPIKES

- **Blank Spikes**

  Blank spikes (organics) were prepared and analyzed at the required frequency.
  _X_Yes
  ____No

Blank spike recoveries were within control limits.
_X_ Yes
___No

8. SURROGATE SPIKES

Surrogate spikes were prepared and analyzed at the required frequency.
_X_ Yes
___No

Surrogate spike recoveries were within control limits.
_X_ Yes
___No

9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.
  _X_ Yes
  ___No

  Matrix spike recoveries were within control limits.
  ___Yes
  _X_No (see following Notes)

  Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

- Matrix spike duplicate samples were analyzed at the proper frequency.
  _X_ Yes
  ___No

  Matrix spike duplicate RPD's were within control limits.
  ___Yes
  _X_No (see following Notes)

  Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from theDecember 2015 monitoring:

  _X_ Lab SC versus field SC
  _X_ Lab pH versus field pH

  Lab SC versus field SC: A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

Lab pH versus field pH: A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

11. HISTORICAL COMPARISON

Current sampling event data (December 2015) were compared to historical data. The data for the December 2015 sampling event compared well to the historic data.

12. DATA QUALITY OBJECTIVES

- **Project data quality objectives (DQO's) met.**

  _X_ Yes
  ___ No

Accuracy

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

Precision

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 99 percent for this sampling event.

Field precision was 99 percent for this sampling event.

Completeness

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

DATA VALIDATION REPORT

Prepared by: **Ericka Vallance**

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REFERENCES

Hem, J.D., 1992. Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition. US Geological Survey Water Supply Paper 2254.

Hydrometrics Project Work Plan. Sampling and Analysis Plan City of Helena Landfill Groundwater Monitoring Activities, March 2008.

U.S. Environmental Protection Agency, 1990. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition.

U.S. Environmental Protection Agency, 1993. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. October 2004.

U.S. Environmental Protection Agency, 1994. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. October 2004.

APPENDIX B

STATISTICAL ANALYSES REPORTS

Validation and Statistic
Evaluation of December 2015
Groundwater Quality Data

City of Helena Landfill

Appendix B - Statistical Analyses Reports

March 2016

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